Getting in Sync

A discussion by Dr. J. Kramer

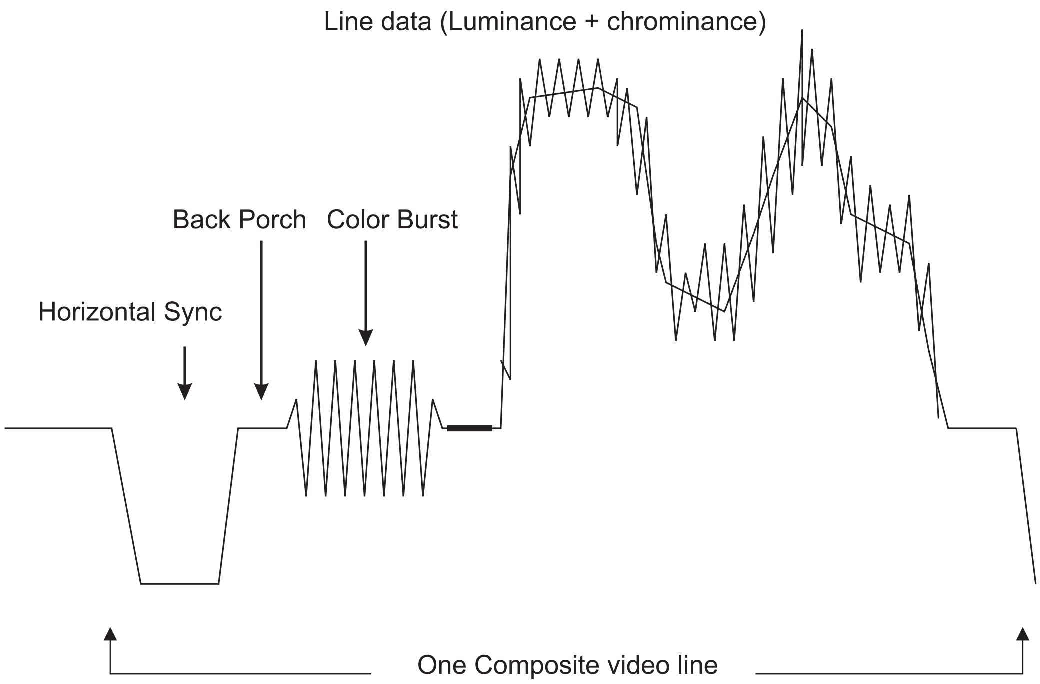
All video signals that end up on a monitor carry with them synchronization information. Whether those are analog signals (Composite, Y/C, Component and RGB) or digital (SDI etc.) The synchronization signals are needed for proper alignment of the image on the screen. Many problems, which are sync, related are sometimes misinterpreted, and other components of the signals are being blamed.

In this discussion I'll try to solve the sync mystery for proper problem understanding and hence solution finding.

Sync types

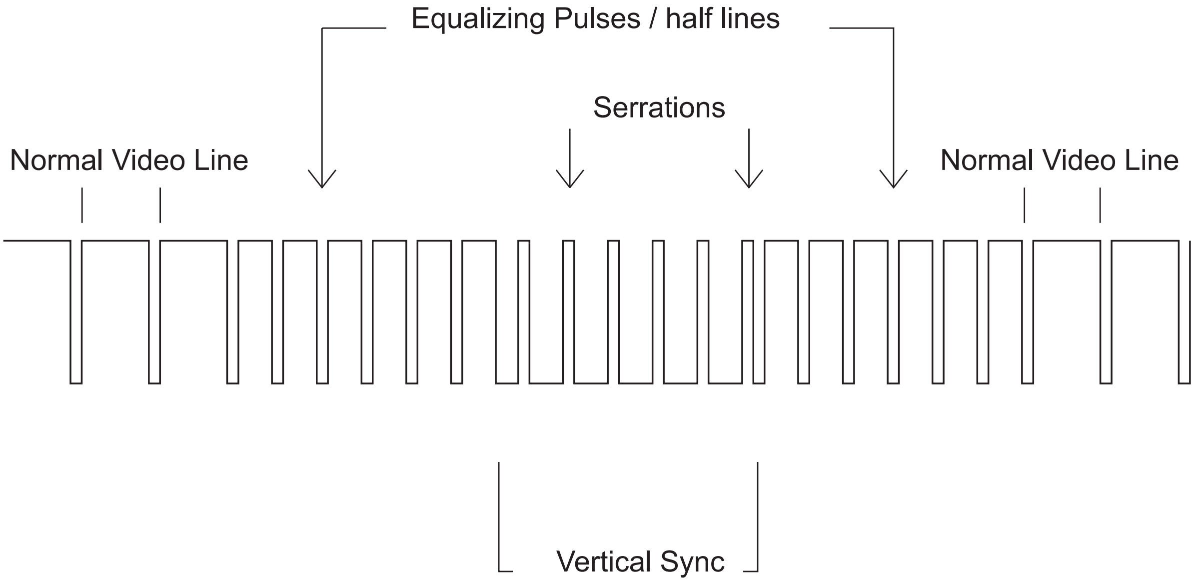
In most known video formats, there are two types of sync signals – the Horizontal sync and the Vertical sync. The Horizontal sync, (often referred to as the Line sync) in a composite video signal is a short, negatively going pulse at the beginning of each scan line of the monitor.

Basically, this pulse "tells" the monitor – "be prepared – a line of data is coming". The Horizontal sync resides in the Blanking area – the unseen part of the signal, therefore, it is not seen on the screen. There is an identical number of Line sync pulses and video lines.



The Vertical sync (sometimes referred to as the Field sync) is again a negative going set of pulses at the beginning of each video field (60 field/sec. in NTSC, 50 fields/sec. in PAL). The Vertical sync is a more complicated signal than the Horizontal sync and it tells the monitor – "be prepared, a new field of data is coming". The Vertical sync also resides in the Blanking area, as is not seen on the screen.

Vertical Sync signal



Sync location

The sync signals appear in the following locations of the different video formats:

- ❑ In the Composite video signal, it is an integral part of the signal as the Composite video signal is comprised of a package including sync information (Horizontal and Vertical), Luminance information and Chrominance (color) information.
- ❑ The s-Video signal format is made of two parts – the Luminance (brightness, black & white information) and the Chrominance (color information). The sync signals in this format are part of the luminance (Y) signal, in a similar manner to that of the Composite video signal.
- ❑ In the Component video signal, which is comprised of three signals – the Luminance signal (Y) and the two color difference signals: R-Y and B-Y the sync signals reside in the Y signal, in a similar way to the Composite and s-Video signals.
- ❑ When it comes to RGB (Red, Green, Blue) signals used in professional computer graphics and display applications, there are several options for the sync signals to be carried along with the data. The first and most common one is a separate Analog Sync channel – and hence the system is comprised on 4 wires carrying signals – and is named RGBS format.
- ❑ Another popular format uses only three wires – Red, Blue (as in the above configuration) and Green+Sync, where the sync rides on the green signal. In this format, the signal levels are not identical as the Green signal has a larger amplitude due to the sync it carries, and the sync signals should be tripped off in order to recover the normal green sync level.
- ❑ A subset of this format inserts the sync signals in all three data channels – e.g., Red+Sync, Blue+Sync and Green+Sync.

- The format generated by a Computer Graphics card is normally made of 5 different signals: Red, Green, Blue, Horizontal sync and Vertical sync (sometimes referred to as Hs and Vs.) To make things more complicated – the data channels – R, G, B are analog channels (their level varies in a continuous way from 0 to maximum) but the sync signals are digital format signals – (TTL level) being either 0 or 1 (0 volts or 5 volts). To make things even more complicated, in contrast to the analog sync signals which are negative-going pulses, the computer generated logic-level syncs can appear in both directions. Sometimes one of the syncs is positive and the other is negative going, sometimes both are either positive or negative going. The sync direction is dictated by the source – the graphics card and is dependent on the required resolution. In the past, the sync direction was messaging the monitor which resolution to choose. Nowadays, most of the monitors are smarter and set the resolution automatically, but nevertheless, the cards still generate those sync signals.
- Another twist to this format is the fact that in most cases the logic-level syncs are separated and are running each in it's own channel, but there are cases when the logic-level syncs come composite – joined together in the same mix of directions.
- In the digital world – SDI, DV, MPEG and other formats, the synchronization signals either travel in a special digital sync channel or, in most cases, are embedded in the digital signal. Retrieving the sync information when embedded in the digital signal involves complicated circuitry and the discussion on problems related to digital syncs will not be presented here.

Some common problems

Very often, problems, which are sync-originated, disguise themselves to a point where it seems that the data is faulty, and the sync section is not suspected at all.

The standard video sync level in Composite, s-Video (Y/C) and Component video formats is approximately 0.3 Volts negative going direction. Most signal acceptors – monitors, VCRs etc., are designed to accept this level without any problem. The tolerance in most cases is quite large – most monitors for example, are able to lock on signals as low as 0.2 Volts or even 0.15 Volts.

This is the basic standard, however, a host of acceptors such as video grabbing cards, special monitors and others require a sync level which is substantially higher: 1 Volt, 2 Volts, 4 Volts and so on. Those acceptors usually have a special sync input socket like in the RGBS format. If those acceptors receive a signal with lower sync levels than they require, the image gets either distorted or vanishes at all – which leads to believe that there is something wrong with the data.

In Composite, s-Video (Y/C) and Component video formats this is usually not happening. When the sync level for some reason goes below acceptable standard level, the image gets distorted or starts rolling on the screen but doesn't vanish.

A common problem in high generation copies is attenuation of the narrow signals surrounding and within the vertical sync – the serration and the equalization pulses that are needed for proper image display on the screen.

The most common effect when the vertical sync is damaged is either a jittery image on the screen or the "flagging effect" where the upper part of the screen is skewing sidewise looking like a flag.

Various processors which insert signals into the Vertical blanking area – such as time code, teletext and copy protection schemes may cause an image instability, mainly due to indirect sync deterioration as a result of the AGC (automatic gain control) function built-in the acceptor, getting unnecessarily activated.

The result is again – image instability, rolling picture on the screen, "Flagging" and a host of other negative effects.

The main cause for the above-mentioned problems is improper analog sync levels. In the logic-level sync world this shouldn't happen. That is in theory.

However, new problems – level oriented also exist in the logic-level sync world.

Up to several years ago, TTL (transistor-transistor logic) standard levels were defined as 0 volts for logic level "0" and 5 Volts (nominal) for logic level "1". There was a certain tolerance from what level "1" starts and what level can already be declared as "0" and most equipment conformed to this standard. In the last years, as computers got faster and faster and hence hotter, it was decided to drop some logic supply voltages down to 3.3 Volts and even lower. When this happened, the "0" level is still 0 Volts, but the "1" level is now 3.3 Volts. Making the "0" and "1" levels to cope with the real world, the tolerance definitions were changed. The bottom line is that in some cases, one device sends a logic signal of "1", while using 3.3 Volts logic (or lower) but the receiving device interprets this level as "0". When it comes to sync signals – this is immediately causing all the negative effects mentioned above.

Besides the logic incompatibility problems (which are quite well treated by most manufacturers using logic-translators circuitry), another "mine-field" is being set.
The computer graphics world is highly linked nowadays to the analog world. A lot of video productions are made, edited and stored in computers. Some are outputted from the computer using special cards, some use the graphics cards themselves.
The analog world needs to get, in most cases, a composite sync signal of 0.3 Volts magnitude. If computer related syncs are transformed to video levels, a problem may arise as following: let's assume that in order to convert a standard logic level sync (5 Volts) to analog video sync levels, a voltage divider from 5 Volts to 0.3 Volts is needed, some 16-fold division. If a logic level of 3.3 Volts is used, running at a lower tolerance of say 2.8 Volts – then the division will result in a sync signal level of 0.17 Volts (2.8 Volts divided in 16.6) – lower than acceptable. There's no need to say what will happen to the analog signal.

Another catch – what if the Horizontal sync is negative going and the Vertical sync is positively going and they should be translated to an analog signal?

The solution site

The first step to choose a solution is to correctly identify the problem.

When data disappears from the screen, the initial response is to look for problems in the data path, but it should be born in mind that it could be a sync-related problem. For a technical person, using an oscilloscope it is quite easy to find what is wrong. Just monitor the data channels and the sync channels – and the answer is straightforward.

Let's assume that the problem was identified to be sync related.

- When analog sync levels are too low then a standard video amplifier with level adjustments should be used. The sync is inserted as a video signal, and by using the controls of the amplifier, the level is adjusted to the standard level.

- When an analog sync signal seems to be distorted at the vertical blanking area – missing equalizing pulses or serrations or having sync disturbing information in this area – then either an expensive solution can be used, such as a TBC (Time Base Corrector) or less expensive, dedicated machines may be used. Such machines – either sync stabilizers – which "clean-up" the teletext, time-code, closed-caption and other information can be used, or, machines that replace the whole Horizontal and Vertical blanking area, as well as the color burst with newly generated signals – such as Black-Burst Restoring devices.

- When logic level syncs are involved, it should be decided whether the sync direction is the problem – (positive instead of negative for example) or the analog-converted sync level is wrong. If the problem results from wrong sync direction, then devices that "rectify" the syncs into the right directions are needed. Sync-direction-rectify processors are usually part of other devices which combine TTL syncs with analog signals (Sync-to-Green Adders for example). Those devices usually comprise additional circuitry that may solve the second problem – syncs with wrong logic level. Those devices include a sync logic-level translator to eliminate the level incompatibility.

- Even when everything seems correct – the sync source generates a signal within it's specifications and the acceptor is designed to accept standard sync information, a quick check whether both machines "talk" the same language is needed. It only takes to read the last page of the manual, where the technical specifications are described.

- In the case that a sync signal rides on all data signals – Red, Green and Blue and if not taken care-of, when the signals are inputted to a machine which accepts Red, Blue and Green+Sync, a wrong color is shown on the output, usually with a purplish tint. This is the result of feeding Red and Blue signals higher than normal (as they "ride" on the sync). To solve this problem, some acceptors have built-in switches or software commands to ignore those weird signals and those controls should be activated, or a "sync-shaver" machine should be used, one for each of the Red and Blue channels. This device "shaves-off" and strips the sync signal off the data signal. This is a very common problem and the above-mentioned simple solution is often ignored.

- Sometimes, a video image shows instability due to slowly rolling horizontal bars. It can be easily assumed that this is a sync-related problem, but very often it's not. Image instability and rolling bars can result from ground-related problems. When two devices are connected with a cable, they may be fed from sources with different ground potentials. The difference in ground potentials (which should be "0" volts by the book) creates a ground induced current that flows with signal, modulates it and creates the phenomenon described above. The solution to this problem is ground isolation. It can be done either by special transformers (that unfortunately might impair the frequency response of the signals involved) or electronic devices – utilizing opto-isolator technology or other electronic means. Checking whether this is the source of the problem or not is easy – it's just measuring, using a voltmeter, whether a ground potential exits between both points. Care should be taken to avoid touching devices or wires carrying dangerous mains voltages.